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Spray Runoff Disposal of Waste Stabilization Pond Effluent

Research Report No. 22



**Research Program for the Abatement of Municipal Pollution
under Provisions of the Canada-Ontario Agreement
on Great Lakes Water Quality**

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These RESEARCH REPORTS describe the results of investigations funded under the Research Program for the Abatement of Municipal Pollution within the provisions of the Canada-Ontario Agreement on Great Lakes Water Quality. They provide a central source of information on the studies carried out in this program through in-house projects by both Environment Canada and the Ontario Ministry of the Environment, and contracts with municipalities, research institutions and industrial organizations.

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SPRAY RUNOFF DISPOSAL
OF WASTE STABILIZATION POND EFFLUENT

by

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Applied Science Section
Ontario Ministry of the Environment

RESEARCH PROGRAM FOR THE ABATEMENT
OF MUNICIPAL POLLUTION WITHIN THE
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ABSTRACT

Effluent from the Smithville municipal waste stabilization pond has been sprayed on a sloping (5 percent) area of soil with a permeability $K \leq 0.14$ in/hr (10^{-4} cm/sec) for two seasons. Results indicate that a combined pond and spray runoff system can reduce the phosphorus loading on a receiving stream by 90 percent and the hydraulic input by 50 percent.

Spray runoff disposal of sewage effluent appears to be a feasible means of upgrading effluent quality provided erosion and/or damage to vegetation does not occur.

RÉSUMÉ

Pendant deux saisons, on a arrosé un sol en pente (5% d'inclinaison) et de perméabilité $K \leq 0.14$ pouces/heure (10^{-4} cm/sec) avec l'effluent de l'étang de stabilisation des déchets municipaux de Smithville. Les résultats montrent qu'un système combinant la stabilisation en étang et l'arrosage de l'effluent sur une pente peut permettre une réduction de 90% de la quantité de phosphore parvenant à une eau réceptrice, et une réduction de 50% de l'apport d'eau.

L'arrosage d'un effluent d'eau usée sur une pente semble une méthode pratique pour en améliorer la qualité, pourvu qu'il ne survienne ni érosion ni dommages à la végétation.

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1. INTRODUCTION

The spray runoff technique for land disposal of sewage effluent has been under evaluation by the Pollution Control Planning Branch of the Ministry of the Environment for two seasons at the Smithville waste stabilization pond site. The project was funded under the terms of the Canada-Ontario Agreement on Great Lakes Water Quality.

This technique, whereby effluent is sprayed along the top of a slope by conventional irrigation sprinklers and subsequently trickles downslope in a thin sheet, has only been used in a limited number of cases. Sepp (1) reported on 30 hillside applications of septic tank effluent in California. A spray infiltration system on a 10 percent slope sparsely forested with pine at Lake Tahoe (2) functioned partially in the runoff mode but produced poor results due to continuous operation without regard to adverse climatic conditions (heavy rainfall, low temperatures). A well-documented study by Thornthwaite Associates (3) on overland runoff disposal of the food processing waste (BOD = 492 mg/l, P = 8.5 mg/l, N = 18.8 mg/l) from the Campbell Soup Co. plant at Paris, Texas demonstrated that a 175 ft (53.4 m) length of runoff on a 2 to 6 percent slope gave effective effluent renovation (removal of BOD = 98.4%, P = 56.3%, N = 88.4%).

Disposal by overland runoff is potentially applicable on sloping sites with a relatively impermeable overburden having a good vegetative cover to control erosion and assist in effluent upgrading (4). Effluent volumes are reduced physically by evaporation, evapotranspiration and possibly infiltration; quality is improved by filtration, adsorption, chemical precipitation, ion exchange, biochemical transformation and biological

absorption. Clay type soils, with a high percent of particles 2 microns in size or smaller, should be particularly suited for spray runoff systems due to their highly reactive surfaces and extremely low hydraulic conductivity rates.

The Smithville study was originally designed to compare the irrigation - infiltration process to runoff disposal on a heavy clay soil with low permeability. During the second phase, emphasis was placed on the runoff operation, determining the effects of antecedent moisture conditions and temperature on runoff coefficients as well as improvement in effluent quality.

2. SITE CHARACTERISTICS

2.1 General

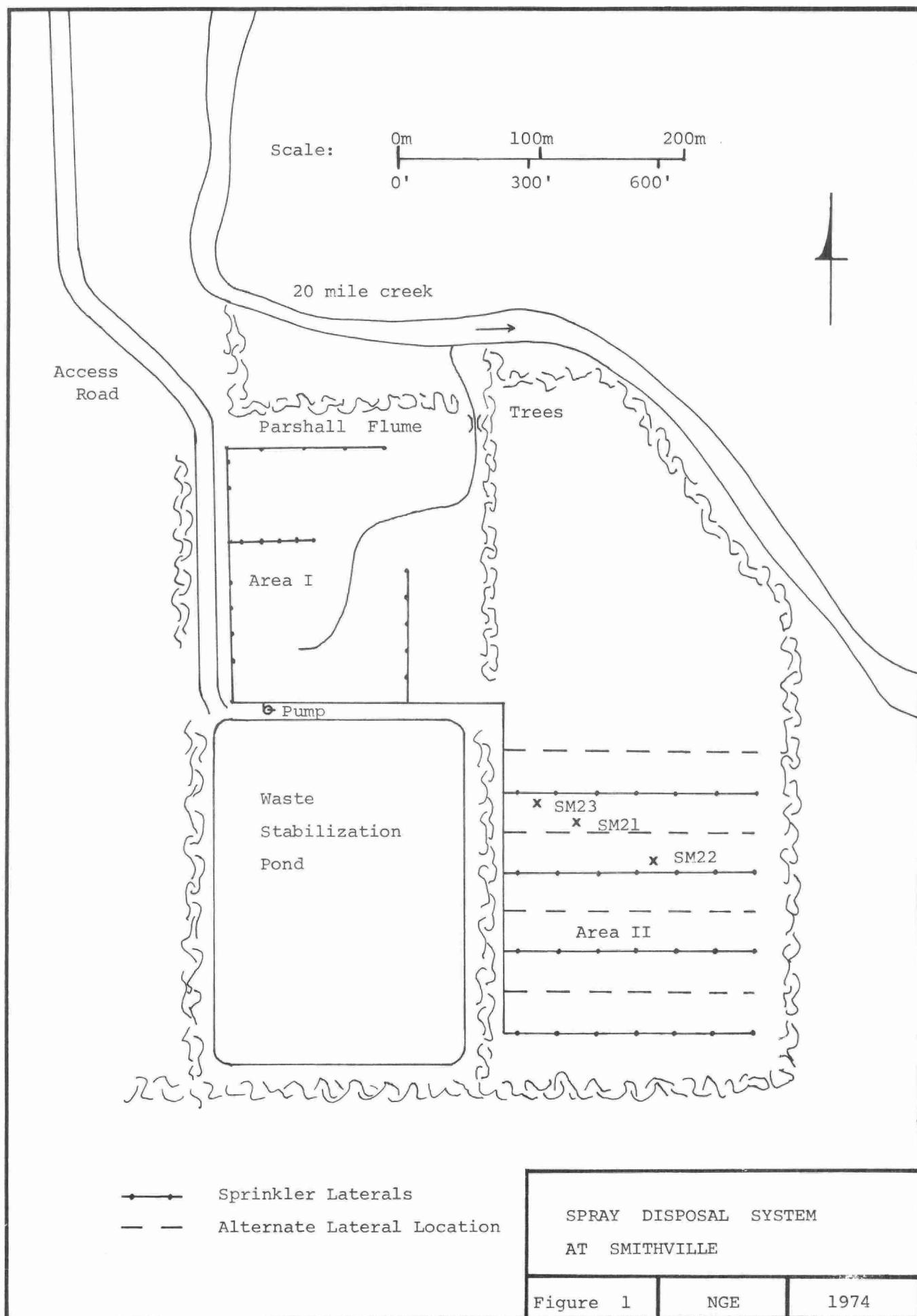
The town of Smithville (pop. 1097) is located near the geographic centre of the Niagara peninsula in southern Ontario. A single 8.52 acre (3.45 hectare) waste stabilization pond is used to treat the municipal sewage which is mainly of domestic origin. Seasonal discharge from the pond provides the main contaminant load applied to 20 Mile Creek, which empties into Lake Ontario. Due to population increase, the design loading of the pond has been exceeded and a two-cell expansion to the system using municipally owned land to the north and east of the original pond is under consideration. This land was made available for the study.

2.2 Topography

A diagram of the disposal sites is shown in Figure 1. The area bounded by the sprinkler laterals to the north (Area I) is approximately 5.1 acres (2.06 hectare), sloping toward the north-east corner at a rate of 5 percent. The area to the east (Area II) is relatively flat and about 8.2 acres (3.32 hectare) in extent.

2.3 Hydrogeology

The overburden in the area consists of Haldimand clay loam and Lincoln clay, both clay tills with a permeability of 0.14 to 0.014 in/hr (10^{-4} to 10^{-5} cm/sec) and a thickness of 20 to 30 feet (7 to 10 m). Results of a soil survey of the two spray areas are given in Appendix I. The underlying bedrock is grey to brown dolomite of the Guelph - Lockport formations of Silurian age. The watertable in both areas was between 15 and 20 feet (5 and 7 m).



2.4 Vegetation

Area I was covered with thick grass and numerous weeds typical of a fallow field. Area II was partially sown with wheat in the fall previous to spraying and resown with clover and timothy in the spring just prior to startup.

2.5 Climatology

A summary of the 10 year (1959-1968) temperature (max. and min.) and precipitation (rainfall and snowfall) data for Smithville is shown in Table 1.

TABLE 1

SMITHVILLE - CLIMATOLOGY*

	Temperature (°F)		Precipitation (inches)	
	<u>Mean Max.</u>	<u>Mean Min.</u>	<u>Rainfall</u>	<u>Snowfall</u>
Jan.	29.2	14.7	1.52	12.8
Feb.	29.8	14.4	1.57	12.3
Mar.	39.1	23.0	1.47	8.5
Apr.	53.3	33.9	2.88	2.9
May	65.0	42.6	2.34	
June	75.5	52.8	2.58	
July	79.6	58.0	2.74	
Aug.	78.4	57.2	4.50	
Sept.	72.4	52.0	2.47	
Oct.	59.4	39.8	2.53	0.5
Nov.	47.0	31.7	2.52	1.8
Dec.	34.5	21.1	1.83	6.9

* Based on 10 year summary (1959 - 1968)

3. OPERATION

3.1 Sampling

To determine improvement in effluent quality due to overland flow, samples SM3 and SM4 were taken from the end of two natural depressions which collected the bulk of the flow from three sprinkler laterals in Area I; the average length of runoff was 260 ft. (78 m) to SM3 and 220 ft. (67 m) to SM4 (see Fig. 2). Samples taken from the end of the lagoon drainage ditch at the Parshall flume (SM5) were used to determine bulk discharge quality.

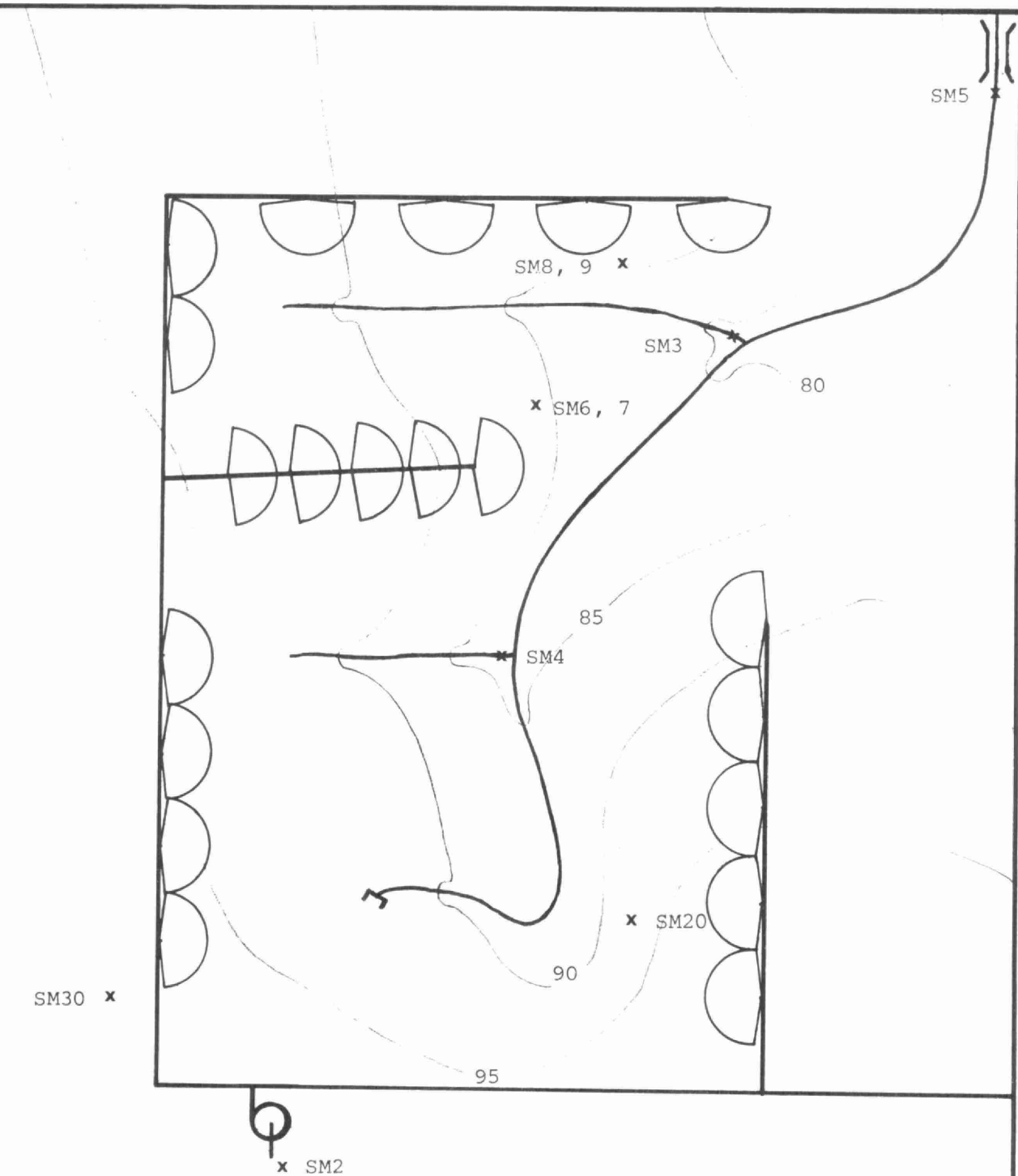
Improvement in quality of the percolate was monitored by samples from surface lysimeters (SM6, SM8, SM22, SM23) containing 3 inches (7.5 cm) of topsoil and related vegetation and root systems in both Areas I and II. Samples from a 10 inches (25 cm) depth (SM7, SM9) were obtained from bucket lysimeters in Area I.

The possibility of groundwater contamination was checked using wellpoints at the 10 ft. (3 m) level (SM20, SM21) and comparing samples from these to groundwater upstream from the spray area (SM30).

3.2 Spray Data

Effluent application rates for both seasons are shown below:

Year	Month	Area I		Area II	
		in/hr	(cm/hr)	in/hr	(cm/hr)
1972	June-July	.148	(.376)	.090	(.229)
	Aug-mid				
	Sept.	.130	(.330)	.079	(.201)
	mid Sept.-				
	Oct.	.117	(.279)	.071	(.180)
1973	June-Oct.	.133	(.338)		



Scale:

0' 50' 100' 150'

Contour Lines
Natural Depressions

AREA I (detail)

Figure 2

NGE

1974

Discharge rates were determined from pressure readings at the individual sprinklers; application rates were determined by summing the individual sprinkler discharges and dividing by the area enclosed by the laterals.

Summaries of the weekly applications of effluent as well as natural precipitation and pan evaporation are shown in Tables 2 and 3. Net precipitation was not determined since a correlation between evaporation from standing water and from sheet runoff was not available.

Total spray volumes and daily rates on runoff Area I are listed below:

<u>Year</u>	<u>Total Spray Volume</u>		<u>Average Daily Spray Rate</u>	
	<u>Ig.</u>	<u>m³</u>	<u>Ig/acre/day</u>	<u>m³/ha/day</u>
1972	8.91 x 10 ⁶	4.05 x 10 ⁴	11,900	133.8
1973	9.33 x 10 ⁶	4.24 x 10 ⁴	13.800	154.8

TABLE 2

WEEKLY SPRAY SUMMARY, 1972 (AREAS I & II).

Date	Rainfall (inches)	Spray I (in.)	Total Precip. I (in.)	Spray II (in.)	Total Precip. II (in.)	Pot. Evap ⁿ . * (in.)
Jun. 5 - 11	0	3.74	3.74	.32	.32	1.74
12 - 18	.15	2.15	2.30	.81	.96	1.24
19 - 25	1.64	1.59	3.23	.32	1.94	.81
26 - Jul. 2	1.03	2.74	3.77	.81	1.84	1.15
Jul. 3 - 9	0.70	3.61	4.31	.40	1.10	1.17
10 - 16	1.05	3.22	4.27	.65	1.70	1.55
17 - 23	0.04	5.59	5.63	0	.04	2.04
24 - 30	0.23	3.39	3.62	0	.23	1.89
Aug. 1 - 6	1.44	3.90	5.34	0	1.44	1.36
7 - 13	2.00	1.69	3.69	0	2.00	1.30
14 - 20	1.03	0.98	2.01	0	1.03	1.55
21 - 27	0.04	0	.04	.95	.99	1.11
28 - Sept. 3	0.70	4.18	4.88	.59	1.29	1.46
Sept. 4 - 10	0.50	3.25	3.75	.67	1.17	1.61
11 - 17	0	4.19	4.19	.44	.44	1.17
18 - 24	0.04	2.98	3.02	.71	.75	1.06
25 - 30	1.17	3.80	4.97	0	1.17	0.75
Oct. 2 - 8	1.10	6.90	8.00	.71	1.81	0.62
9 - 15	0.10	9.63	9.73	.75	.85	0.67
16 - 22	0	5.93	5.93	.33	.33	0.49
23 - 29	<u>1.13</u>	<u>3.72</u>	<u>4.85</u>	<u>.33</u>	<u>1.46</u>	<u>0.27</u>
Total	14.09	77.18	91.27	8.79	22.88	25.01
Average	0.67	3.68	4.35	.42	1.09	1.19

* Potential Evaporation Data from Royal Botanical Gardens, Met. Station, Burlington, Ontario.

TABLE 3

WEEKLY SPRAY SUMMARY, 1973 (AREA I)

<u>Date</u>	<u>Rainfall (in.)</u>	<u>Spray (in.)</u>	<u>Total Precip. (in)</u>	<u>Pot. Evap. (in)*</u>
May 28 - June 3	.85	.68	1.53	1.15
June 4 - 10	.20	-	.20	1.73
11 - 17	.70	6.70	7.40	1.67
18 - 24	.90	4.42	5.32	1.26
25 - 30	.45	2.28	2.73	1.00
July 2 - 8	-	**	-	-
9 - 15	-	**	-	-
16 - 22	-	**	-	-
23 - 29	.06	3.58	3.64	1.64
30 - Aug. 5	-	6.83	6.83	1.61
Aug. 6 - 12	-	9.30	9.30	2.18
13 - 19	-	1.30	1.30	1.39
20 - 26	-	4.97	4.97	1.21
27 - Sept. 2	-	3.48	3.48	1.78
Sept. 3 - 9	-	7.38	7.38	1.89
10 - 16	-	5.30	5.30	1.36
17 - 23	1.20	6.53	7.73	.81
24 - 30	-	4.55	4.55	.88
Oct. 1 - 7	1.05	5.01	6.06	.60
8 - 14	-	3.19	3.19	.76
15 - 21	-	2.08	2.08	.58
22 - 28	-	3.32	3.32	.54
Total	5.41	80.90	86.31	24.04
Average	.29	4.26	4.54	1.27

* Pot. Evaporation data from Royal Botanical Gardens Met. Station, Burlington, Ontario.

** Spraying temporarily discontinued due to crop harvesting.

4. RFSULTS

4.1 Fractional Runoff

Due to the topography of the runoff area (Fig.2), any applied effluent which was not lost by infiltration, evaporation or evapotranspiration eventually collected in the main drainage ditch and discharged to the creek. The volume of this runoff was determined by a continuous level recorder connected to a Parshall flume located in the ditch. Using the ratio of the runoff to the volume of liquid applied, the fractional runoff x_R was determined.

The dependence of x_R on climatic conditions was apparent on a seasonal basis in 1972 and on the 5-day antecedent moisture conditions (AMC; see Appendix II) in 1973 within a 95 percent confidence limit. Although it was expected that the rate and/or duration of application would have some influence on the fractional runoff, no statistical proof could be established. A summary of fractional runoffs x_R and their 95 percent confidence limits is shown below:

<u>Year</u>	<u>Season</u>	<u>AMC</u>	<u>x_R</u>
1972	Summer	III	.516 $\pm$.279
	Fall	III	.663 $\pm$.325
1973		I	.340 $\pm$.072
		II	.564 $\pm$.148
		III	.492 $\pm$.045

As the bulk of spray operations was carried out under AMC III conditions, x_R values for this condition were used to determine quantitative losses of effluent for nutrient mass balance relationships (Section 4.2).

4.2 Nutrient Removal in Runoff

The effectiveness of effluent land disposal is best demonstrated by grouping the waste stabilization pond and irrigation systems together. The degree of treatment at each stage is shown in terms of absolute values in Table 4(a); mass percent removals in the runoff relative to raw sewage are tabulated in Table 4(b) using the fractional runoff x_R (Section 4.1) to account for quantitative decreases in the effluent volume. Using the percentages in Table 4(b), equivalent concentrations (defined as the concentrations of total phosphorus, BOD and SS that would be present in the runoff if none of the effluent was lost by infiltration etc.) in the runoff were calculated and tabulated in Table 4(c).

No significant difference in removal of phosphorus, nitrogen, BOD and SS was observed between the two lengths of runoff. This could be due to the sprinkler distribution (see Figure 2) producing a lower localized application rate ($0.17 \text{ in/hr} \equiv 0.44 \text{ cm/hr}$) over the shorter length than with the greater distance ($0.21 \text{ in/hr} \equiv 0.53 \text{ cm/hr}$). The average phosphorus equivalent in the runoff was 1.07 mg/l ; BOD equivalents were consistently less than 15 mg/l .

Sample results from the drainage ditch were not indicative of the system's performance as the suspended solids concentrations evince scouring of sediment deposits from the ditch.

TABLE 4

NUTRIENT CONCENTRATION AND REMOVAL IN RUNOFFAREA 1 (1972, 1973)

(a)

1972	Average Concentrations mg/l					
	Pt	Ps	NH ₃	Kjel	BOD	SS
Raw Sewage	11.8				208	256
Effluent	6.4	3.8	6.4	14.6	39	65
Runoff (260')	2.2	1.4	1.0	3.3	12	31
Runoff (220')	2.1	1.4	0.7	5.6	22	36
Drainage Ditch	2.9	1.7	1.5	7.0	26	257
<u>1973</u>						
Raw Sewage	10.6	6.5			258	329
Effluent	8.1	5.1	11.9	27.3	75	86
Runoff (260')	2.1	1.3	0.7	6.2	23	31
Runoff (220')	1.5	0.8	0.5	5.7	20	68
Drainage Ditch	4.1	2.7	3.4	9.5	34	136

(b)

1972	Mass Percent Removal					
	Pt	Ps	NH ₃	Kjel	BOD	SS
Runoff (260')	89	78	91	87	97	95
Runoff (220')	90	78	94	77	94	94
<u>1973</u>						
Runoff (260')	90	90	97	89	96	95
Runoff (220')	93	94	98	90	96	90

(c)

1972	Equivalent Concentration (mg/l)		
	Pt	BOD	SS
Runoff (260')	1.30	6.2	12.8
Runoff (220')	1.18	12.5	15.4
<u>1973</u>			
Runoff (260')	1.06	10.3	16.5
Runoff (220')	.74	10.3	32.9

4.3 Nutrient Removal in Percolate

The change in effluent quality due to infiltration into the overburden was observed by analyzing percolate samples from surface and subsurface lysimeters and wellpoint piezometers. The rate of infiltration was estimated from the time taken for chloride (Cl^-) anion in the effluent to appear at the different sample depths.

Nutrient contents of the percolates in the low-rate infiltration field (Area II) and the runoff Area I are summarized in Tables 5 and 6 respectively. Phosphorus levels were reduced consistently below 1 mg/l in the first 3 inches (7.5 cm) of soil in the low rate area; ammonia nitrogen was generally 1 mg/l or less and nitrate contamination was minimal. Renovation of the percolate in the runoff area was not as good as in Area II due to much heavier hydraulic loadings. Phosphorus levels were consistently below 1 mg/l after passing through the first 10 ft. (3 m) of topsoil; ammonia levels averaged less than 1 mg/l.

Chloride levels in the two piezometers and the effluent increased linearly with time (Fig. 3). The jump in Cl^- concentration in the test piezometer between 7 and 9 weeks was not apparent in the correlation but was used as an estimate of the time for breakthrough of the anion. As this piezometer provided samples from the 10 foot (3 m) level, a percolation rate of between 0.08 and 0.1 in/hr (5.6 and 7.1×10^{-5} cm/sec) was determined. The difference in chloride levels between the effluent and lysimeter samples was not significant; the increase of chloride levels in the test piezometer above that of the effluent could be due to desorption of the anion from a soil having minimum absorbing capacity.

TABLE 5

NUTRIENT CONCENTRATION AND pH IN INFILTRATION AREA II (1972)

Month	Sample	P _T	P _S	NH ₃	Kjel	NO ₂ ⁻	NO ₃ ⁻	pH
June	SM2*	7.0	2.9	5.0	16	.27	.3	8.7
	SM22	-----	Insufficient Sample		-----	-----	-----	
	SM23	-----	"		"	-----	-----	
	SM21	-----	"		"	-----	-----	
July	SM2	4.0	2.7	4.0	9.5	.23	.2	8.5
	SM22	.3	<.1	.1	1.0	.01	<.1	7.1
	SM23	.6	.1	.6	1.5	.01	.19	7.3
	SM21	.45	<.1	.1	1.0	.06	.04	7.5
August	SM2	5.7	3.4	5.4	12	.04	.2	8.2
	SM22	.6	<.1	1.0	8.0	.01	<.1	7.4
	SM23	.5	<.1	.4	2.0	.01	<.1	7.4
	SM21	.17	<.1	.2	1.0	.01	<.1	7.6
Sept.	SM2	8.0	6.1	8.3	22	.05	.1	8.3
	SM22	-----	Insufficient Sample		-----	-----	-----	
	SM23	-----	"		"	-----	-----	
	SM21		<.1	0.6		.03	<.1	7.2
Oct.	SM2	7.7	5.9	1.3	19	.06	<.1	7.8
	SM22	.17	<.1	.11	1.1	.01	<.1	7.1
	SM23	.85	.1	1.4	5.5	.01	<.1	7.1
	SM21	.64	<.1	.11	4.1	.014	.1	7.6

* SM2 - Effluent from Lagoon
 SM22 - Surface Lysimeter (3")
 SM23 - " " "
 SM21 - Wellpoint Piezometer (10')

All values in mg/l except pH.

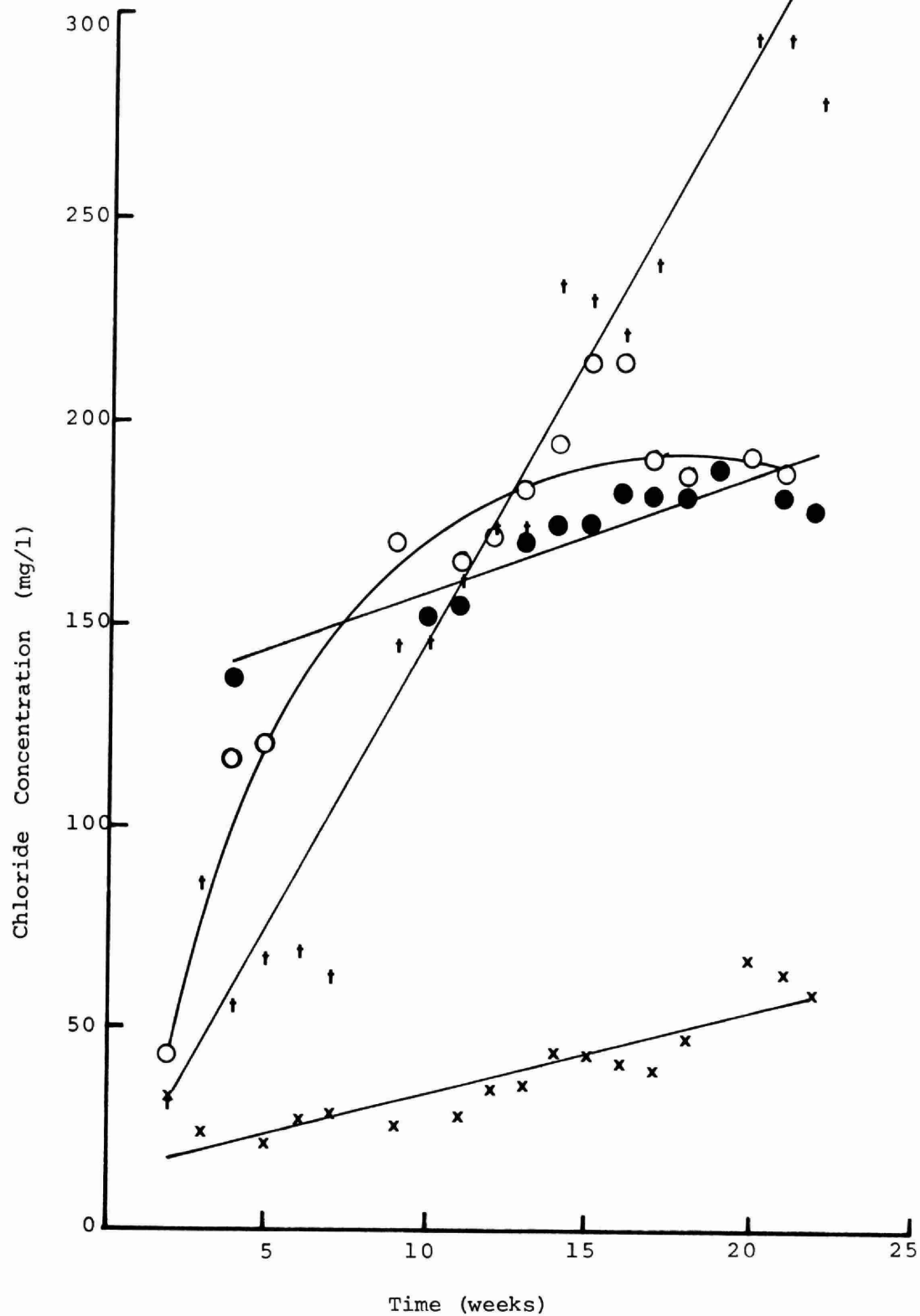
TABLE 6

NUTRIENT CONCENTRATION AND pH IN RUNOFF AREA I (1973).

Month	Sample	P _T	P _S	NH ₃	Kjel	NO ₂ ⁻	NO ₃ ⁻	pH
May	SM2*	5.8	5.0	13	20	.01	<.1	7.8
	SM7,9	.54	.17	.55	6.5	.07	.1	7.0
	SM20	.43	.01	.3	2.0	.01	<.1	7.7
	SM30	.25	.05	.1	2.5	.01	<.1	7.3
June	SM2	7.6	2.9	14	24	.03	<.1	7.9
	SM7,9	1.3	.28	1.3	6.8	.02	<.1	6.9
	SM20	.51	.012	.4	3.6	.018	.01	7.4
	SM30	.19	.016	.2	1.3	.005	<.01	7.4
July	SM2	9.0	5.9	16	39	.02	.08	7.7
	SM7,9	2.1	.22	4.1	24	.03	.14	7.2
	SM20	.74	.09	2.3	7.6	.31	.5	7.3
	SM30	.11	.01	.3	1.0	.004	.02	7.5
Aug.	SM2	7.6	4.5	9.3	24	.05	.1	8.1
	SM7,9	1.6	.47	1.4	7.2	.06	<.1	7.2
	SM20	.35	.09	1.1	4.0	.02	.12	7.2
	SM30	.16	.01	.17	0.9	.14	.23	7.4
Sept.	SM2	8.1	4.8	9.0	26	.02	<.1	7.9
	SM7,9	3.0	1.2	3.4	10	.1	<.1	7.4
	SM20	0.6	.15	1.3	5.1	.01	<.1	7.4
	SM30	0.3	.11	.56	1.1	.02	<.1	7.4
Oct.	SM2	8.7	6.0	15	30	.02	<.1	7.9
	SM7,9	2.0	0.7	3.3	9.4	.08	.3	7.1
	SM20	0.5	.02	0.5	3.6	.02	<.1	7.4
	SM30	0.3	.04	0.7	2.4	.04	<.1	7.4

SM2 - Effluent from Lagoon -
 SM7,9- Subsurface Lysimeter (10")
 SM20 - Wellpoint Piezometer inside runoff area (10')
 SM30 - Piezometer outside runoff area (Control)

All values in mg/l except pH.



- Effluent
- Subsurface Lysimeters
- x Control Piezometer
- † Test Piezometer

CHANGE IN CHLORIDE CONCENTRATION WITH TIME

Figure 3

NGE

1974

5. DISCUSSION

Although the fractional runoff " x_R " found in this study was numerically similar to the runoff coefficient "C" used by hydrologists in the rational method ($Q = Ci A$), the usage differs. The " x_R " factor may be applied to the sprayed volume of effluent to predict the reduction in loading on a receiving stream by the overland runoff method.

Since the bulk of the spray operations were carried out under AMC III conditions during the summer, a system similar to that at Smithville could be expected to reduce the effluent volume by about 50 percent. Despite the apparent lack of correlation between either rate or duration of application and fractional runoff, an upper limit should be imposed to prevent erosion and/or damage to vegetation. This limit would be determined by visual inspection.

The fractional runoff determined at Smithville was less than the $x_R = 0.61$ found at similar application rates in the Paris, Texas study (3) where remolding the watershed resulted in a lower roughness coefficient "n".

The equivalent total phosphorus and BOD levels in the runoff met with current discharge standards for sewage treatment plant effluents, suspended solids levels did not and this may have been due to minor erosion.

Although this study was primarily concerned with improving effluent quality via overland runoff, analysis of the percolate samples demonstrated the adsorptive capacity of the clay soil and vegetation for nitrogen and phosphorus. Chloride desorption or negative adsorption of anions occurred as would be predicted by the assumption of an unequal ion distribution in the diffuse double layer according to the Donnan equilibrium and the Guoy theory (5).

The linear increase in chloride in the effluent and piezometers occurred within the spray period and extrapolation beyond this range is not recommended.

6. CONCLUSIONS AND RECOMMENDATIONS

On the basis of data obtained at the Smithville, Ontario test site, where waste stabilization pond effluent was sprayed on a relatively impermeable clay soil with an average slope of 5 percent during the growing season of two consecutive years, the following conclusions are drawn:

1. A combined waste stabilization pond-runoff system can reduce the phosphorus loading on a receiving stream by 90 percent.
2. Hydraulic input to the receiving stream may be reduced by up to 50 percent.
3. Spray runoff disposal is a feasible means of upgrading effluent quality provided the rates and duration of application do not result in erosion and/or vegetation damage.

Based on these conclusions, it is recommended that spray runoff disposal of sewage effluent be considered as a viable system for effluent polishing purposes where a relatively impermeable soil ($K \leq 0.14$ in/hr) on a sloping terrain is available.

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PROJECT STAFF

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APPENDIX I

MECHANICAL ANALYSIS OF SMITHVILLE SOIL

<u>U.S. Bureau of Soils Classification</u>	<u>Area I</u>	<u>Area II</u>
% Find Sand	3	6
% Silt	19	22
% Clay	78	72
Lab Textural Class	H.Cl.	H.Cl. (Med Cl)
<u>Unified Soil Classification</u>		
Liquid Limit	52.0%	53.0%
Plastic Limit	28.0%	28.0%
Plasticity Index	24.0%	25.0%
Group Symbol	CH	MH

APPENDIX II

TOTAL 5-DAY ANTECEDENT RAINFALL (RAINFALL IN PREVIOUS 5 DAYS)

<u>AMC</u>	<u>Dormant Season</u>	<u>Growing Season</u>
I (Dry enough for satisfactory cultivation; lowest runoff potential)	<0.5"	<1.4"
II (Average conditions; not well defined)	0.5 to 1.10	1.4 to 2.1
III (Practically saturated watershed from previous rains)	>1.10	>2.1